**5.6: Time Series Analysis & Forecasting**

**1. Create a time series using the instructions provided in the Exercise.**

Figure 1: The chart shows the client’s monthly revenue ($) over the times

**2. Observe the pattern of the line in your time series and answer the following questions:**

**- What characteristics does the pattern display (e.g., seasonality, stationarity)? Write a short paragraph to explain your answer.**

- What advice might you give

Figure 3: The client’s monthly revenue ($) in 1993

Figure 2: The client’s monthly revenue ($) in 1992

Figure 5: The client’s monthly revenue ($) in 1995

Figure 4: The client’s monthly revenue ($) in 1994

The dataset shows a clear pattern of **seasonal** characteristics. I divided the chart by year and observed that the same pattern repeats each year (the figures above are samples of the dataset from 1992 to 1994). The trend indicates that revenue spikes every November and December. I assume there is a significant factor related to the winter season that boosts sales during this period, such as Thanksgiving, Christmas, and New Year holidays.

One thing to keep in mind is that this could also be a **non-stationarity** characteristic. When looking at the overall chart, we can see an upward trend, but there were noticeable drops from May 2008 to September 2010, which disrupts the consistent pattern. Therefore, I would conclude that this dataset demonstrates both non-stationarity and seasonality.

**- What advice might you give your client based on this time series. Why?**

As mentioned above, this chart shows an upward trend pattern over the years. However, what makes me hesitate is the drop in revenue from May 2008 to September 2010, which could have been caused by an external disturbance that disrupted the trend. Nevertheless, the chart still exhibits a strong seasonal trend, even during the period when total revenue dropped from May 2008 to September 2010.

What I would recommend is that the company plans and budgets for both high and low seasons. For example, they should prioritize and focus on inventory (such as Christmas presents and decorations), marketing campaigns, and staffing and budget allocation during peak seasons.

Additionally, given the revenue drops observed between 2008 and 2010, I would recommend the analyst team to investigate the reasons behind these declines. It is important to understand the factors contributing to these drops, as they could occur again in the future, even within the context of the overall upward trend.

**3. Create a simple moving average using the instructions in the Exercise.**

Figure 6: The chart shows the average oil prices from 1987 – 2019

**4. Observe the pattern/trend of the oil price line in relation to the five-year moving average line and answer the following questions**

**- Is there a certain characteristic to the pattern and trend? Make sure to provide a short explanation for your answer.**

This dataset demonstrates non-stationary characteristics because it exhibits fluctuations, and its mean and variance have changed over time. As we can see, the data was relatively stable from 1987 to 1998, then began to climb in 1999, followed by a sharp drop in 2008. Overall, from 1987 to 2008, there was an upward trend with fluctuations. The price from 2008 to 2019 swung up and down, showing continued fluctuations. This non-stationarity results in an unpredictable pattern, making it difficult to forecast future values.

I am also checking for seasonal characteristics by examining the chart. It shows that there are no repeated patterns in any specific months.

**- Explain how the moving average affects oil price volatility and how it makes forecasting easier.**

The moving average method is helpful when the original dataset has many fluctuations. This scenario is a good example of using the moving average method to analyze oil prices over time. If we only consider the original dataset, we cannot clearly identify a pattern due to the fluctuations. This could confuse beginners who do not have a clear understanding of statistics and analysis. By using the moving average method, short-term fluctuations and noise are smoothed out. As shown by the orange line on the chart, we can clearly see the pattern, where oil prices started to climb until 2016 and then dropped. This is a helpful method for analysis.

**5. This Exercise mainly looked at non-stationary time series. Briefly explain why you might convert a non-stationary time series into a stationary time series before applying a forecasting model.**

The main advantage of stationarity is that it maintains a constant mean and variance over time. This means that both the mean and variance remain stable, making it easier to identify patterns visually and interpret the data. Once the time series is converted to stationary, we can make better predictions because the stationary data has a clear and consistent pattern.

Additionally, the advantage of using a stationary time series over a non-stationary one is its stability. When a time series is stationary, the relationships between past and future observations become more consistent, allowing the model to generate more accurate predictions based on historical data.

**6. There are lots of other forecasting models, such as the Autoregressive Integrated Moving Average (ARIMA) model.**

**- Do some research on the ARIMA model and one other model not covered in this Exercise; Facebook Prophet is one example that’s become popular in recent years.**

1. **The ARIMA model** uses past data from a time series to analyze patterns and make predictions about the future. It looks at how the data has changed over time and uses this information to forecast future values using statistical techniques.

2. **Facebook Prophet model** is a free tool that makes time-series forecasting easier and faster. It’s designed for people who don’t have a lot of experience with statistics, because it automates many steps. Prophet combines traditional forecasting methods with modern machine learning. Unlike ARIMA, which can be hard to set up and doesn’t always work well with complex seasons, Prophet is simpler and more effective. It breaks down the data into three main parts: trend, seasonality, and special events like holidays**.**

In conclusion, ARIMA works well for standard time series with consistent trends and stable variance, whereas Facebook Prophet is better suited for handling more complex, real-world time series that feature irregular patterns, multiple seasonal effects, and external factors.

**- Imagine you have to explain these models to a colleague who’s unfamiliar with them. Write two short paragraphs (1 for each model) without going into the technical details. Include links to the resources you found during research.**

**The ARIMA model** looks at past data to understand trends and predict future outcomes. It examines how the data has changed over time and uses that information to make educated guesses about what might happen next.

**Facebook Prophet** is a free tool that makes it easy and quick to predict future data. It's designed for people who may not be experts in statistics, as it automates many of the steps. Prophet combines traditional forecasting techniques with newer methods. Unlike ARIMA, which can be difficult to use and doesn’t always handle complex seasonal patterns well, Prophet is simpler and works better. It breaks the data into three key parts: the overall trend, repeating patterns, and special events like holidays.

**References:**

<https://corporatefinanceinstitute.com/resources/data-science/autoregressive-integrated-moving-average-arima/>

<https://datascientest.com/en/facebook-prophet-all-you-need-to-know>